Organisation for Economic Co-operation and Development (OECD)
Global Science Forum

Conference on Scientific Challenges for Energy Research

Paris, May 17/18, 2006

<u>Chairman's Summary</u>

The OECD conference took place over two days in May 2006. It brought together 180 technical and policy experts from 28 countries. The preparations were supervised by an International Steering Committee that was nominated by Global Science Forum delegations. The participants were nominated by the delegations or invited by the Steering Committee. This report was prepared by the Chairman of the Steering Committee, Dr. Bernard Frois. It does not necessarily represent the views of the Conference participants.

Introduction

Global energy demand continuously increases. The energy production should double during the next fifty years to satisfy the needs of dynamically growing countries, notably China, India, Brazil and others. Energy will have to be produced through using a variety of traditional and new sustainable technologies. But fossil fuels will, for many countries, continue to constitute an abundant and affordable source of energy. The corresponding increase of greenhouses gas emissions is now perceived as one of the greatest danger for the future of our planet; the predicted impact on the world economy alarms many experts and policymakers.

The central question is whether the energy resources of the planet will be sufficient to sustain the growing needs of the world population. New energy sources must be found, in particular for the transportation sector and for electricity production. Providing the energy needed to satisfy the ambitions of a growing world population for a decent living standard will not be easy. Doing it without greatly increasing the already worrying risks of climate change will be exceptionally difficult.

Sustainable and clean energies are the focus of the attention of most governments. The greatest promise and opportunities are often linked to the most difficult obstacles and challenges. Thus, the goal of the conference was to identify the principal scientific and technological challenges for R&D in the energy sector, and explore the implications for research policy.

The conference focused on policy-level questions:

- Are the right scientific areas being supported?
- What is the correct balance between government- and industry-sponsored R&D (including government-industry partnerships)?
- Is governmental funding for energy research adequate for meeting anticipated energy needs by mid-century?

1. **Significant gains are possible by using novel energy technologies.**

The conference presentations showed that advances in science and technology can lead to significant additions to global energy supplies at mid-century. There are large stocks of exploitable energy in many forms and there are no fundamental obstacles to exploiting these resources, in terms of the known principles and laws of physics, chemistry and biology. The challenge is to transform the available energy into usable forms at a reasonable cost in a friendly form to our environment, respecting the requirements of public safety, reliability and economics, as well as other social, political considerations.

In the area of solid-state photovoltaic technology, for instance, the theoretical maximum efficiency for converting sunlight to electricity in of the order of 70% due to the very high temperature of the primary energy source: the surface of the sun at approximately 6000 degrees Kelvin. By contrast, today's commercial solar cells have efficiencies in the 20% range, and a variety of promising ideas exist for moving closer to the theoretical limit. The development of solar-generated electricity has continuously progressed over the years, in particular in Japan. The question remains, however, whether existing levels of R&D effort are consistent with the promise of this technology.

2. **It is imperative to act now against global warming.**

The best peer reviewed science expresses without doubt that there will be a steady increase in the global temperature, in the range of 1.8 to 4° Celsius by the end of the century. The possible consequences of this prediction by the Intergovernmental Panel on Climate Change are frightening. Even the present stock of carbon dioxide would take hundreds of years to dissipate naturally. The only option left is to decrease as much as possible the flux of greenhouse gases emissions, by saving energy and using cleaner technologies. Nicholas Stern's 2006 report (released after the Paris Conference) estimates that it is possible to effectively fight global warming by using only 1% of the world combined GDP, compensated by an increase in world productivity. This is an attractive solution, but it will require a global effort and well defined coherent government policies. One of the most important conclusions of the conference is that it is possible to lower the risks to acceptable values by using a variety of new energy technologies.

3. **Energy R&D needs a higher priority in the science policy process.**

Three generic domains currently form the core of an advanced innovative research agendas in developed countries: nano-science, advanced molecular and cellular biology, and information science. These are directly relevant to many energy applications, but those applications do not always receive the optimal recognition and priority in the science policy process. Thus, for example, while funding agencies have been very generous in funding advanced biology, the motivation has traditionally been on applications for enhancing human health, rather than energy-relevant applications such as creating micro-organisms that feed on organic waste material and produce methane or hydrogen as energy sources.

4. Fossil fuel-based technologies will remain competitive for a long time.

It was repeatedly asserted during the conference that new technologies will be hard-pressed to compete with established mature technologies that are based on the burning of fossil fuels: oil, coal and natural gas. Supplies of fossil resources are still abundant, even though the "era of cheap oil" may be drawing to a close. If fuel prices remain at a level that is relatively high - but still below that which could cause a global-scale recession - alternative sources of fossil fuels become economically attractive, for example tar sands and oil shales. These have the significant advantage, compared with oil and gas, of being much more widely distributed geographically. Thus, elevated energy costs favour both existing technologies and new, alternative ones (which may be inherently expensive initially, and require significant new investments). The fossil fuel-based system will "fight back" via improved efficiencies and lower costs – achieved, in many cases, through the application of advanced science and technology. It was indeed pointed out that, historically, the energy system has been very conservative and resistant to change. The internal combustion engine, the steam turbine, the lead-acid battery, the electric motor: all of these basic components of the energy system have not changed in their essence for many decades. Furthermore, the feasibility of adopting new solutions cannot be evaluated solely on the basis of the incremental production cost per unit of energy. Energy systems require vast infrastructures for distribution and utilization. For example, in the all-important transportation sector there is an enormous existing stock of gasoline- and diesel-powered vehicles, plus a corresponding constellation of tankers, refineries, service stations, etc., not to mention the huge number of transportation professionals whose training and competence is linked to the existing system.

5. Carbon Capture and Storage (CCS) is a powerful technology to use against global warming, but policy-level guidance is needed.

Resolving the issues of carbon dioxide emissions and global climate change is a major goal of research and energy policy. This problem now dominates analyses and projections of the energy future, and the debates about the desirability/feasibility of energy technologies that produce various amounts of carbon. Many energy stakeholders, notably, those based in industry, are frustrated by the uncertainties and delays associated with a lack of an international governmental consensus about the magnitude, time scale, and urgency of the fight against global warming.

Corporate planners and R&D managers are willing to make long-term commitments to low-carbon technologies if they have stable economic conditions (prices, customer base, etc). On numerous occasions, conference participants expressed concern about the uncertainty that prevails regarding the follow-on (if any) to the United Nations Framework Convention on Climate Change ("Kyoto Protocol") which expires in 2012. Similarly, the volatility of the carbon trading scheme has not yet inspired the kind of confidence that is needed for long-term planning and investment in new technologies.

6. A renewed interest in nuclear energy is justified.

The growing interest in nuclear energy is due in large part to its negligible greenhouse emissions and its long term economic competitiveness. Increasingly, the public debate about the future of nuclear power acknowledges the progress achieved in overcoming technological obstacles in the four major areas of concern: reactor safety, long-term management of nuclear wastes, control of radioactive materials, and nuclear proliferation. The prevailing opinion among scientists and engineers is that there are no significant technological obstacles to the development of a new generation of advanced safe reactors with a sustainable fuel cycle, and secure long-term management of nuclear wastes.

Nuclear power is available now and will remain an option for the future as long as there is no proven alternative with the required potential. No other carbon free energy source is available for large- scale production at the multi-gigawatt scale. To keep the nuclear option open, research is of paramount importance to develop improved designs, maintain and renew expertise, whilst continuing to build competence in operation and decommissioning of the present generation of reactors.

7. New energy technologies differ widely in their readiness for practical utilization.

New energy solutions that were discussed at the conference differ widely in terms of developmental stages, spanning the range from basic research, to development, to product design, to feasibility testing, to commercial deployment. Advanced biotechnologies for example, are still in early, basic research phase, but the promise is enormous. For example, CO2 capture is feasible using existing technology, much of which is commercially available, but more progress remain to be achieved in terms of costs. The Oxy-fuel" process, using high-temperature combustion, needs significant additional work, but is perceived as the solution of the future. The various storage scenarios need major R&D to insure the required level of safety at the large scale projected facilities. A number of medium scale facilities exist providing important data. However, there is a need for better instrumented demonstration facilities to allow industry to design future facilities, and for governments to establish robust safety regulations. Industry is ready to make large investments, provided that governments have well defined policies, in particular concerning the period beyond 2012.

8. Findings relevant to R&D policies

The conference addressed the question whether the size and scope of the research effort are commensurate with the desired results. Are governments spending enough on energy-related R&D? Are the right areas of research being funded?

Given the vast demand for new energy production and given also the risks associated with a continued dependence on fossil fuels, an urgent commitment is needed to energy R&D. Should it be accompanied by massive new investments in research? Many nongovernmental groups have issued calls for major shifts in research policy. To cite one typical example, the scientific academies of the G8 countries, plus China, India, Brazil and South Africa (each of the academies brings together the most prominent researchers of the given country) jointly published an appeal to the July 2006 G8 summit meeting in Saint Petersburg. The joint statement "calls on all countries of the world […] to cooperate in identifying common strategic priorities for sustainable and secure energy systems, in implementing actions towards those strategic priorities, and to:

[…]

- Address the serious inadequacy of R&D funding and provide incentives to accelerate advanced energy-related R&D, also in partnership with private companies
- Focus governmental research and technology efforts on energy efficiency, non-conventional hydrocarbons and clean coal with CO2 sequestration, innovative nuclear power, distributed power systems, renewable energy sources, biomass production, biomass and gas conversion for fuels."

The principal elements of energy and R&D policies are as follows:

R&D Policy	Energy Policy
Strategic planning	Economic growth requirements and demand projections
Funding processes and systems	Environmental priorities - climate - other environmental considerations: pollution, land use, biodiversity, etc.
Organisation and oversight	Security of energy supply - long-term resource depletion - geopolitics - price of energy
International collaboration	Security of energy infrastructure (natural and man-made threats)
Intellectual Property Rights	Societal safety and security - nuclear (plant safety, proliferation, waste management) - Biosecurity (inc. bioethics) - Agricultural policy - Lifestyle, aesthetics
Education and training of researchers	
Facilities and other research infrastructures	
Public versus private funding, public/private partnerships	

It is, of course, impossible to accurately predict the course of scientific research, where progress often occurs in serendipitous ways. The OECD conference participants pointed out that policymakers are in, general, not adequately informed about the potential of energy research and about what the research system can be reasonably expected to deliver as a function of time (for example, in terms of lowered prices and greater efficiency of new renewable energy sources). Science policy professionals need to know more about national policy requirements and constraints, while energy policymakers need better information about the state of scientific and technological progress and realistic prospects for the future.

For most participants to the conference, the intensity of efforts on new energy technologies R&D has is not sufficient and well focused to have the necessary impact on energy production by mid-century. Given that overall funding levels are moderate and many promising directions of research remain to be explored, there is clearly a need to do more to ensure that national research systems are functioning at a level that truly reflects the anticipated future needs. The principal conclusion of the Conference is that research policy and energy policy need to be harmonized and coordinated to a far greater degree than is currently the case.